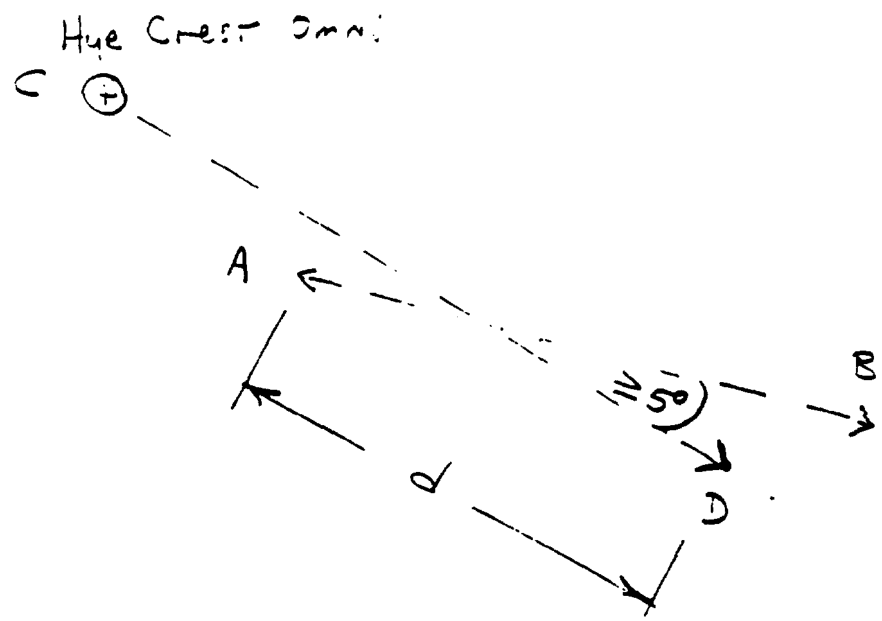

Figure 3.

its subscriber receivers provided that its transmitters are at least 1000 feet from and angled at least 5 degrees from the Hye Crest omnidirectional transmitter (or 10 degrees and 581 feet).

Case 4) WHEN THE POINT-TO-POINT SYSTEM IS OUTSIDE OF THE 4 TO 5 MILE SERVICE CELL RADIUS OF THE HYE CREST SYSTEM (See Figure 4.) NO INTERFERENCE WITH A HYE CREST SUBSCRIBER RESULTS REGARDLESS OF SIGHTING DIRECTION.

Consider a subscriber receiver D1 located directly along the AB path as shown in Figure 4. To be conservative, assume zero distance between A and B. D1 is the only Hye Crest subscriber aimed directly at the interference transmitter A. Since it is at the opposite side of the service area it is 5-10 miles from A. Consider the 10 mile case first, since at this range it receives the weakest desired signal from C.

The path loss FSL for 28 GHz at 5 miles is found from Equation 1 to be 145.5 dB. The victim receiver antenna gain is 38 dB reduced by 25 dB for cross polarization for a net G(DA) = +13 dBi. Substituting these values with those used in the previous interference calculation into Equation 10 and solving for I(D) gives

$$\begin{aligned} I(A) &= +28\text{dBW} - 145.5\text{dB} + 13\text{dB} - 25\text{ dB} \\ &= -129.5\text{ dBW} \end{aligned} \qquad \text{Equation 13.}$$

Since I(A) is more than 3 dB below the noise floor of -116 dBW at D, no interference occurs when the victim receiver is at the 10 mile range. If the range is reduced to 5 miles then I is increased by 6 dB, but this is also well below the noise floor and it can be concluded that no interference is experienced by and Hye Crest subscriber who faces a point-to-point system operating outside of the 5 mile service cell radius.

Consider the case where the point-to-point transmitter is at point D3 and a Hye Crest receiver is at point D3, both along axis, AD. The FCC rules maintain a 55 dB antenna backlobe isolation which when added to the 50 dB of isolation due to interleaving and cross-polarization yields a minimum 105 dB of loss to be added to path loss. Assuming a point-to-point EIRP of +28 dBW and a receiver MDS of -116 dBW the required path loss is 39 dB [FSL = -116 dBW + 105 dB - 28 dBW = -39 dB] for the interfering signal to be at noise level of the Hye Crest receiver.

Then

$$\begin{aligned} \text{required FSL} &- 39\text{ dB} \\ \text{FSL} &= 36.58 + 20\log(F) + 20\log(d) \\ 39 &= 36.6 + 88.9 + 20\log(d) \\ 20\log(d) &= -86.5 \\ d &= 0.3\text{ feet} \end{aligned}$$

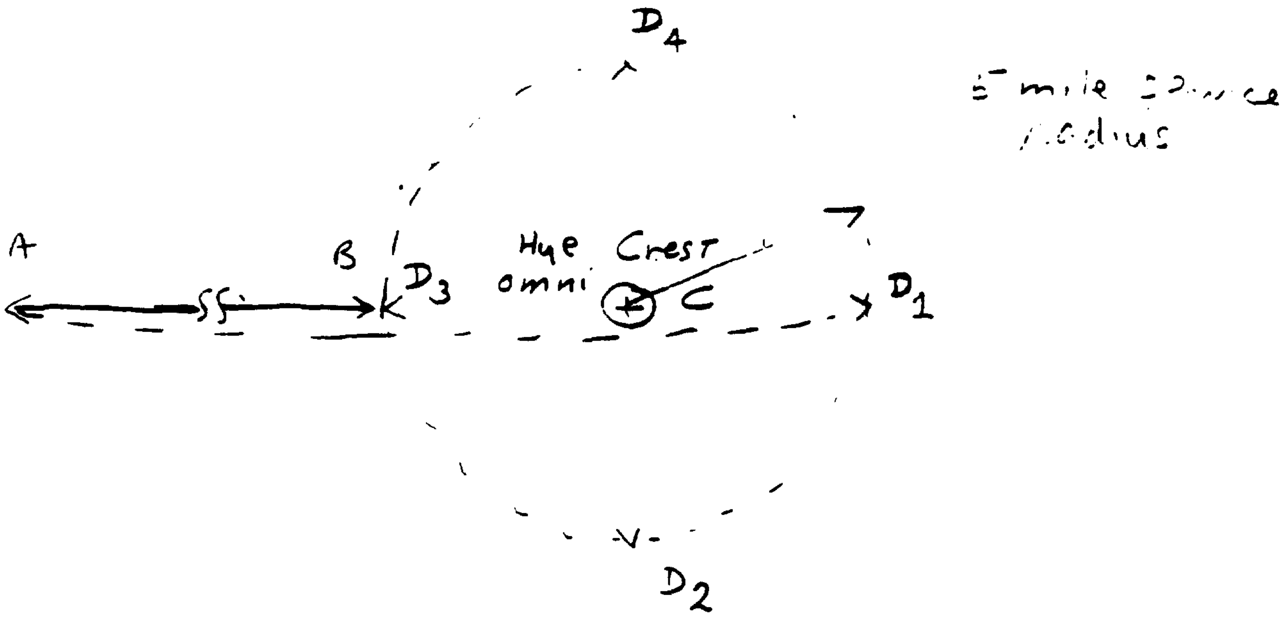

Figure 4.

Consequently, assuming cross-polarization isolation, channel interleaving and backlobe antenna isolation, a point-to-point transmitter could be located very close to a Hye Crest receiver without causing harmful interference.

General Observation

The inherent interference isolation properties of the Hye Crest system of 74 dB (made up of 24 dB antenna gain reduction, 25 dB orthogonal polarization, and 25 dB overlapped channel interleaving) plus any amount of path loss creates a very large interference rejection, to the point where the interference is below the receiver noise level.

This 74 dB of isolation, even before path loss is taken into account, is an overdesign margin when one considers various proposals in which, for example, it is suggested that co-channel dual polarization alone can double route capacity.[2] In those proposals, the 25 dB gained from polarization diversity alone is claimed to be sufficient to prevent interference between two systems operating with the same antennas, frequencies and modulation.

2

- "Further Trends in Microwave Radio: A View from Asia", IEEE Communications, Nov. 87 (Kohiyama and Kurita).
- "Future Trends in Microwave Radio: A View from North America", IEEE Communications, No. 87 (Meyers and Prabhu).
- Reference 5, pp. 254-256.

REFERENCES

1. Roger L. Freeman; RADIO SYSTEM DESIGN FOR TELECOMMUNICATIONS (1-100 GHz); Wiley Interscience, John Wiley and Sons, N.Y., 1987.

2. Roger L. Freeman; REFERENCE MANUAL FOR TELECOMMUNICATION ENGINEERING; Wiley Interscience, John Wiley and Sons, N.Y., 1985.

3. George Calhoun; DIGITAL CELLULAR RADIO; Artech House, Norwood, Massachusetts, 1988.

4. Bobby Harrell; THE CABLE TELEVISION TECHNICAL HANDBOOK; Artech House, Norwood, Massachusetts, 1988.

5. Larry J. Greenstein, Mansoor Shafi; MICROWAVE DIGITAL RADIO; IEEE Press, New York, New York 1988

6. FCC Rules and Regulations

APPENDIX A

This is a UHF television channel interference calculation, using the unrealistic assumption that the earth is flat (K = infinity).

Consider Channel 56 in Boston, Massachusetts and calculate the interference range under the flat earth (K = infinity) assumption.

The relevant transmitter and receiver specifications are:

Frequency (TV Channel 56):	725 MHz
Transmitter Power (FCC max. allowed = +97 dBm):	+83 dBm
Transmitting Antenna Gain:	0 dB
Minimum Detectable Signal (MDS) of TV receiver:	-110 dBm
(Based on 6 MHz IF bandwidth and 10 dB Noise Figure (NF))	
Receiver Antenna Gain:	17 dB

The free space loss (FSL) that can be accommodated under these conditions is related to the transmitter power and receiver sensitivity by:

FSL = EIRP + G - MDS
where
EIRP is the effective isotropic radiated power at the transmitter (in dBm)
G is the gain of the receiving antenna (in dB)

Solving for FSL under the assumed conditions,

FSL = +83 dBm + 17 dB -(-100 dBm)
= 200 dB

This is the amount of free space path loss which must be encountered by a television signal before another non interfering television station can be established. But the FSL due to simple propagation, in the absence of earth curvature effects, is given by

$$\text{FSL (dB)} = 36.58 + 20\log(F) + 20\log(d)$$

where
F = transmitter frequency (MHz)
d = transmitter to receiver path (statute miles)

If this is solved for the distance of propagation necessary to provide 200 dB of loss at 725 MHz, the result is

$$200\text{ dB} = 36.58 = 20\log(725) + 20\log(d)$$
$$20\log(d) = 106.21$$
$$d = 204{,}485\text{ miles (8 times around the earth)}$$

Thus, using the flat earth (K = infinity) assumption would suggest that a TV channel will propagate 8 times around the earth, thereby allowing only one TV station to operate at this channel assignment worldwide. Clearly, this is inconsistent with the common practice of reusing television channel frequencies spaced only a few hundred miles apart. Note that this analysis assumes a C/I = 0 dB. If we were to use C/I = 75 dB then the distance becomes over one billion miles.

Therefore, interference calculations as made by NSMA using the flat earth assumption are unrealistically pessimistic, and, as can be seen, if applied to broadcast television would preclude ever reusing channel frequencies worldwide.

APPENDIX B

Example of Point-to-point Coexistence with Point-to-Multipoint Operation.

It is generally accepted that an earth station has the potential for causing the greatest interference to nearby terrestrial facilities along the horizontal direction relative to its antenna. Section 25.205 of the FCC Rules and Regulations states that within the band 5925 to 6425 MHz, the mean effective radiated power transmitted in any direction in the horizontal plane by an earth station shall not exceed +40 to +55 dBW in any 4 kHz band, depending on elevation angle (at angles up to 5 degrees).

The Hye Crest radiated power in the horizontal direction is only +5 dBW in a 40 MHz band (-35 dBW in a 4 KHz band). This is 80 dB below customary FCC rules for the 6 GHz band.

If one were to apply a C/I = 75 dB, the nearest distance a point-to-point 6 GHz system could operate from a satellite earth station would be 125,000,000 miles, as the calculation below shows. Clearly, this situation, too, is inconsistent with common practice. Thus, the C/I = 75 dB is too stringent a requirement to apply as a general rule in interference calculations. In addition, even with a C/I of 0 dB, a strict application of interference formulas would suggest that point-to-point and point-to-multipoint could not share the same band, within 22,000 miles yet as a practical matter they do.

The interference distance is determined according to the following calculation.

Transmission Frequency, F.	6 GHz
EIRP (in horizontal plane):	+45 dBW (+75 dBm)
MDS of receiver (40 MHz bandwidth, 12 dB NF):	-86 dBm
Transmitter antenna gain:	0 dB
Receiver antenna gain:	38 dB
Assumed necessary C/I ratio:	75 dB

Using these values, the necessary free space loss (FSL) is then calculated to be

FSL = EIRP + G(rec) - MDS + C/I
= 75 dBm + 38 dB -(-86 dBm) + 75 dB
= 274 dB (required loss to avoid interference)

Solving the distance formula to determine the separation of transmitters necessary to avoid interference under this assumed set of conditions gives,

$$\begin{aligned} FSL &= 36.58 + 20\log(F) + 20\log(d) \\ 274\text{ dB} &= 36.58 + 20\log(6000) + 20\log(d) \\ 20\log(d) &= 274 - 36.58 - 75.56 \\ &= 162\text{ dB} \end{aligned}$$

$d = 125{,}000{,}000+$ miles

Even if the C/I ratio is set equal to 0 dB, the value for

$$20 \log(d) = 87 \text{ dB}$$
$$d = 22{,}000+ \text{ miles}$$

APPENDIX C

Power Levels and Path Lengths in the 28 GHz Band for Point-to-Point Communication

The NSMA assumption of a +55 dBW EIRP for a 28 GHz point-to-point link is totally unrealistic, because this power level is not economically feasible in this frequency range.

Transmitters in the point-to-point communication band at 23 GHz typically utilize 100 milliwatts of transmitter output power from a solid state amplifier. With an antenna gain of 38 dB (18" diameter parabolic antenna), this gives a net EIRP of +28 dBW. The beamwidth for a 38 dB gain antenna is approximately 2 degrees.

Because of rainfall attenuation, the use of higher power levels achieves very little in the way of longer reliable path lengths.

Rainfall attenuation is the critical factor limiting the range of radios operating at 23 or 28 GHz. For example, a 99.5 reliability of communication factor in the New England region (8.5 hours of below-standard performance per year) requires a 5 dB per mile factor of safety. In order to double the 5 mile point-to-point range to 10 miles would require an extra 31 dB of power output (6 dB additional path loss plus 5 dB/mile times 5 miles).

The power output requirement to achieve a 10 mile path would then be 125 watts, a level only obtainable by tube amplifiers which cost nearly $100,000 each. A full redundancy duplex system would then cost more than $400,000. It would require an EIRP of +59 dBW, which exceeds the maximum of +55 dBW allowed by the FCC Rules and international regulations.

Operation at 20 miles would require 62 dB more power or 158,500 watts which is neither technically feasible nor legally permissible.

Thus, for point-to-point operations, the 23 and 28 GHz frequency bands are useful only for short range communications because of rain attenuation. It is not realistic to employ these frequencies for longer paths. Moreover, it is unrealistic to use a +55 dBW EIRP level in interference calculations, because this power level results in enormous costs while achieving only modest path length increases.

APPENDIX D

Equations

1. FSL (dB) = 36.58 + 20log(F) + 20log(d)

   FSL = Free Space Loss
   F = Carrier frequency in megahertz
   d = Distance in statute miles

2. MDS = -204 dBW + 10log (BW) + N.F.

   MDS = The noise floor in dBW at 290 degrees K (17 degrees C) or minimum discernible signal.
   -204 dBW = kTB
   BW = bandwidth in Hertz
   NF = noise figure of receiver

3. MTS = MDS + C/N
   MTS = minimum threshold signal
   MDS = minimum discernible signal
   C/N = carrier to noise ratio required for FM threshold,

the point at which FM enhancement occurs. Above the threshold point the relationship between S/N and C/N is linear on a decibel-by-decibel basis.[3]

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[3] pp. 337 Electronic Transmission Technology, William Sinnema, Prentice Hall 1988 Second Edition

AFFIDAVIT OF DR. JOSEPH F. WHITE

I, Joseph F. White, being duly sworn, do depose and state as follows:

1. I am an engineering consultant specializing in microwave theory and techniques retained by Hye Crest Management, Inc. Additional information concerning my engineering background and activities in Attachment A hereto.

2. I prepared with Bernard B. Bossard the Engineering Exhibit which is attached to the foregoing supplement to the Response of Hye Crest Management, Inc. in File No. 10380-CF-P-88. Except for those factual matters of which official notice may be taken or which are matters of public record, the statements made in that engineering exhibit are true, complete and correct to my personal knowledge.

DATE: Jan 19, 1989

Joseph F White
JOSEPH F. WHITE

Subscribed and sworn before me this 19 day of January, 1989 ~~1988~~.

Jane A Linden
NOTARY PUBLIC

My commission expires: March 5, 1993

Affidavit of Dr. Joseph F. White
Attachment A

The following is a supplement to the affidavit of Dr. Joseph F. White, 7 Hadley Road, Lexington, MA 02173, Telephone Number (617) 863-9603.

I, Dr. Joseph F. White, received my BSEE Degree from Case Institute of Technology (Cleveland, Ohio) in 1960, my MSEE from Northeastern University (Boston, MA) in 1965 and my Ph.D. from the Department of Electrophysics at Rensselaer Polytechnic Institute (Troy, New York) in 1968.

From 1961-1987 I was employed by M/A-Com (Burlington, MA) ultimately as Vice President and Technical Director of the Corporate Technology Center.

I have given lectures on Microwave topics at the following institutes: Chalmers University Gothenberg, Sweden; The University of Michigan Microwave Semiconductor Devices and Circuits intensive short course, and the Toshiba Research Labs, Tokyo. I also lectured in China as a member of the 1983 IEEE MTT Study Tour of Shanghai, Nanjing, Chendu, Xian and Beijing.

I also have given numerous evening lectures for the IEEE Microwave Theory and Techniques local groups through the United States and am currently the President of the Boston Chapter of this organization.

I am a Fellow of the Institute of Electrical Engineers (IEEE), a member of its Microwave Theory and Techniques and Electron Device groups, and a member of the honorary societies, Eta Kappa Nu and Sigma Xi.

I am the author of MICROWAVE SEMICONDUCTOR ENGINEERING, (Van Nostrant Rheinhold, NY 1982) a recognized text and reference on microwave engineering and its applications for the use of semiconductors at microwave frequencies.

In 1975 the IEEE MTT Group awarded me with its Application Award given annual to one individual chosen for his contributions to the microwave field.

Since 1977, I have been the Consulting Editor for the MICROWAVE JOURNAL magazine. I am also a private consultant.

AFFIDAVIT OF BERNARD B. BOSSARD

I, Bernard B. Bossard, being duly sworn, do depose and state as follows:

1. I am an electrical engineer specializing in microwave system theory and integration, retained by Hye Crest Management, Inc. Additional information concerning my engineering background and activities is shown in Attachment A hereto.

2. I prepared with Joseph F. White the Engineering Exhibit which is attached to the foregoing supplement to the Response of Hye Crest Management, Inc. in File No. 10380-CF-P-88. Except for those factual matters of which official notice may be taken or which are matters of public record, the statements made in that engineering exhibit are true, complete and correct to my personal knowledge.

Date: 1/9/89

BERNARD B. BOSSARD

Subscribed and sworn before me this 9th day of January, 1989.

NOTARY PUBLIC

My commission expires: 6-23-89

Donald E. Church
Notary
My Commission Expires June 23, 1989

Affidavit of Bernard B. Bossard
Attachment A

The following is a supplement to the affidavit of Bernard B. Bossard, 9 Onondaga Lane, Medfield, MA 02052, Telephone (508) 359-4447.

I am President of I/TTIC, a systems integration company and Group Publisher of Telecommunications, Microwave Journal, and Defense Electronic Magazines.

I have published 26 articles of which the following have direct bearing on interference:

- Pan, Bossard, Burns, Chang, "Systems Concepts of Microwave Communications", 1964 NEREM (Invited Paper).
- Bossard, Totione, Yuan, "Theory and Improvement of Intermodulation Distortion in Mixers", 1964, Tri Service Electromagnetic Compatibility Conference.
- Pan, W.Y., Bossard, B.B. "Receiver Distortions and Reductions", University of Pennsylvania 1965, Summer Lecture Series.
- Pan, W.Y., Bossard, B.B. "Systems Concepts of Radio Interference", University of Pennsylvania, 1964, Summer Lecture Series.
- Bossard, B.B., "Communications Application of Cryogenic Techniques", National Science Foundation Summer Lecture Series, University of Colorado, 1965.
- Perlow, S., Bossard, B.B., "Effective Receiver Dynamic Range Enhancement", 1966, Frequency.
- Bossard, B.B., Markard, E., Levin, P., "Co-Channel Intermodulation and Cross Modulation Reduction Circuit", Proc. IEEE December 1967.

I had total engineering responsibility for communications system design, interference reduction technology, and anti-jamming concept, while with the RCA Communications Laboratory.

I have three patents, U.S., including #4747160 for multifunction cellular system.

I was the principle investigator of the 24 month study on "Interference Reduction Techniques" sponsored by the United States Signal Corps, Ft. Monmouth.

I acted as microwave consultant to the following major programs:

- Relay Satellite
- Lunar Excursion Landing Radar Module (LEM)
- TRC-97 Marine Corps Radio

- Various U.S. Government Agencies: NSA, RADC Wright Filed, Sandia, and Ft. Monmouth

I have been a guest lecturer on microwave communications at Northeastern University (1987).

I was chairman of the millimeter circuits session at the 1988 IEEE MTT-S Symposium.

I have lectured for two years in the University of Pennsylvania summer lecture series (1964-1965) on "Systems Concepts of Radio Interference" and "Receiver and Distortion and Reduction".

I have a BSEE from the Virginia Military Institute.

I was formerly President of KMC (now part of MA/COM) and National Electronic Laboratories (now part of Harvard Industries). I have served as a Member of the Board of Directors of seven Microwave companies.

PRELIMINARY TEST DATA

FROM MANUFACTURER

\- - - - - - - -

For 180° Transmit Antenna

TEST DATA FOR 27.5-29.5 GHz TRANSMIT HORN

JOB: 8814
CUSTOMER: Suite 12

TEST RESULTS:

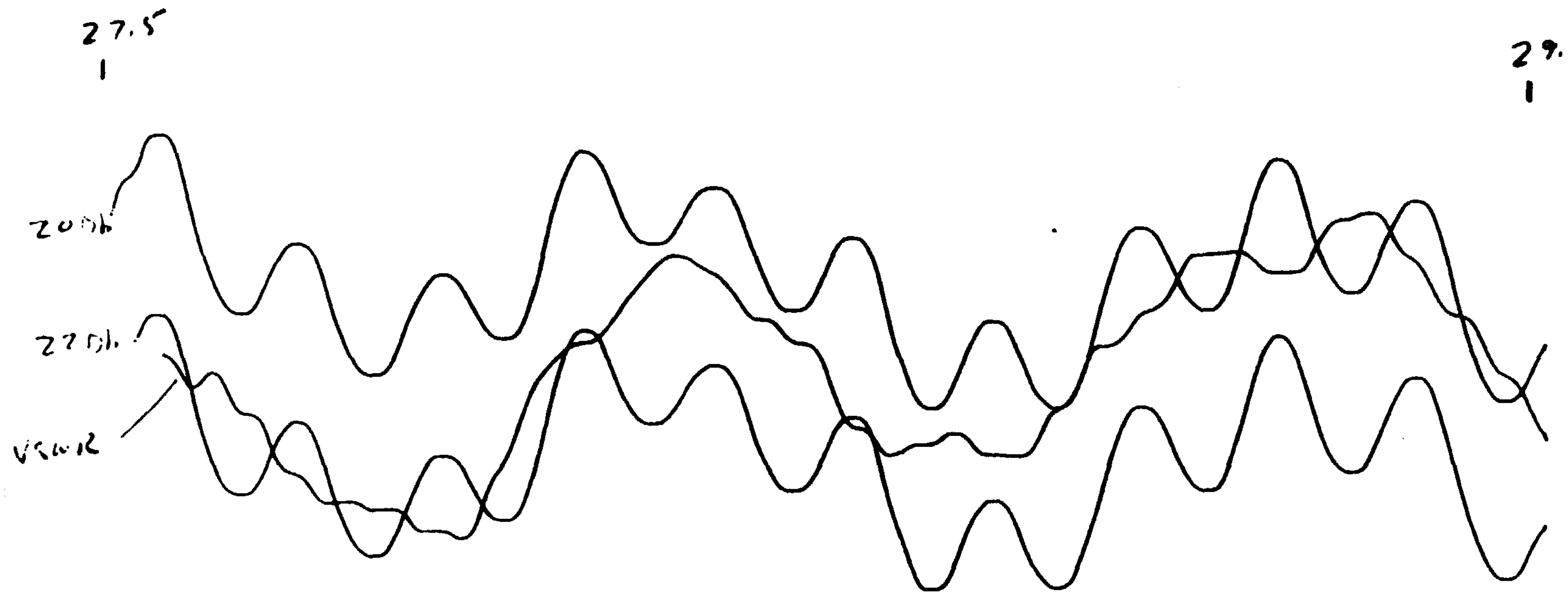
Swept VSWR - 19 dB min (1.25:1 max)

3 dB Beamwidth

Frequency	Azimuth	Elevation
27.5 GHz	180°	21.7°
28.5 GHz	180°	28°
29.5 GHz	180°	28°

NOTE: See enclosed plots.

Test Conditions VSWR



Cust. P/N

Seavey P/N 8814

S/N

Date 9/14/88

Technician SK

Inspector

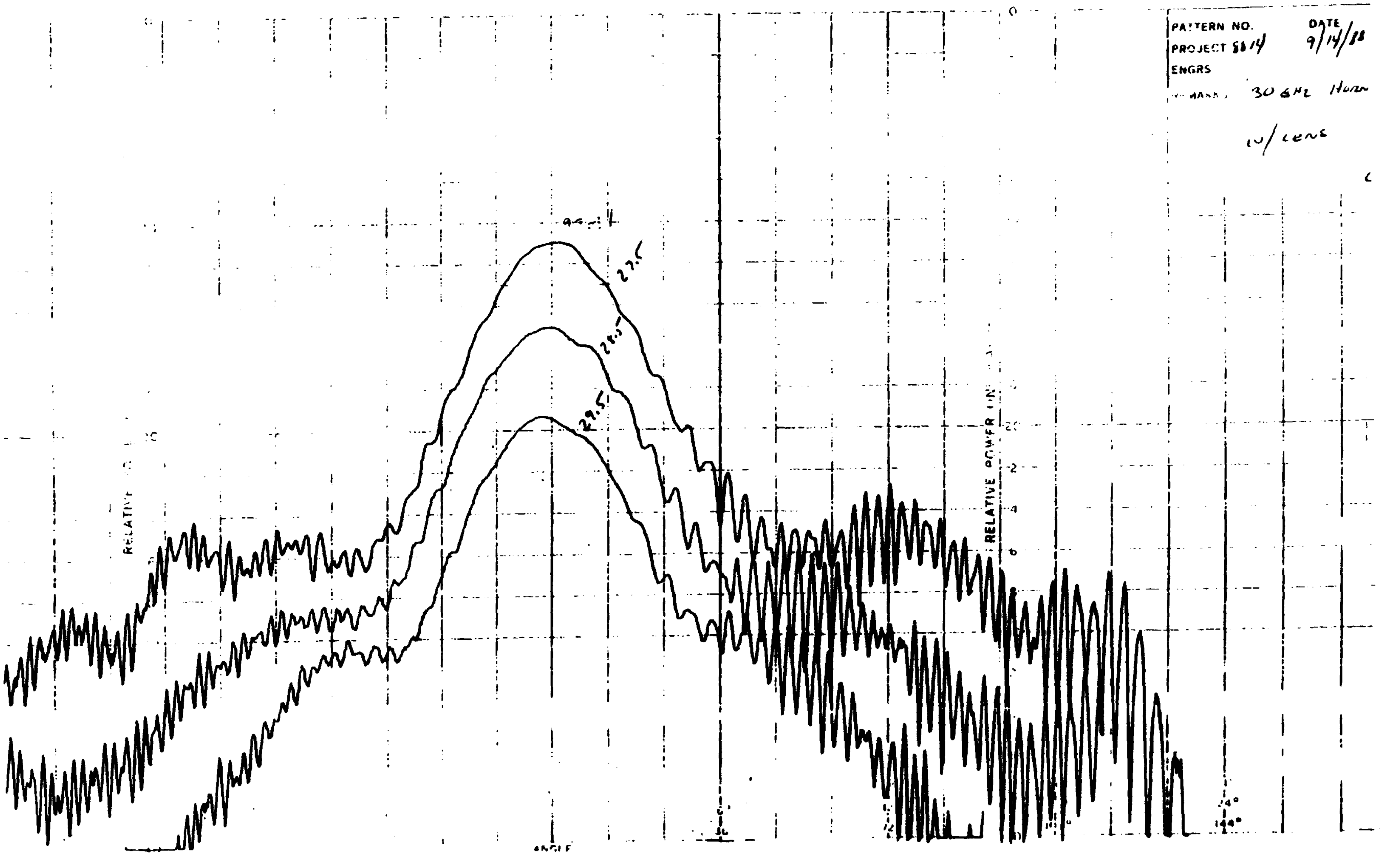
Spec. Ref.

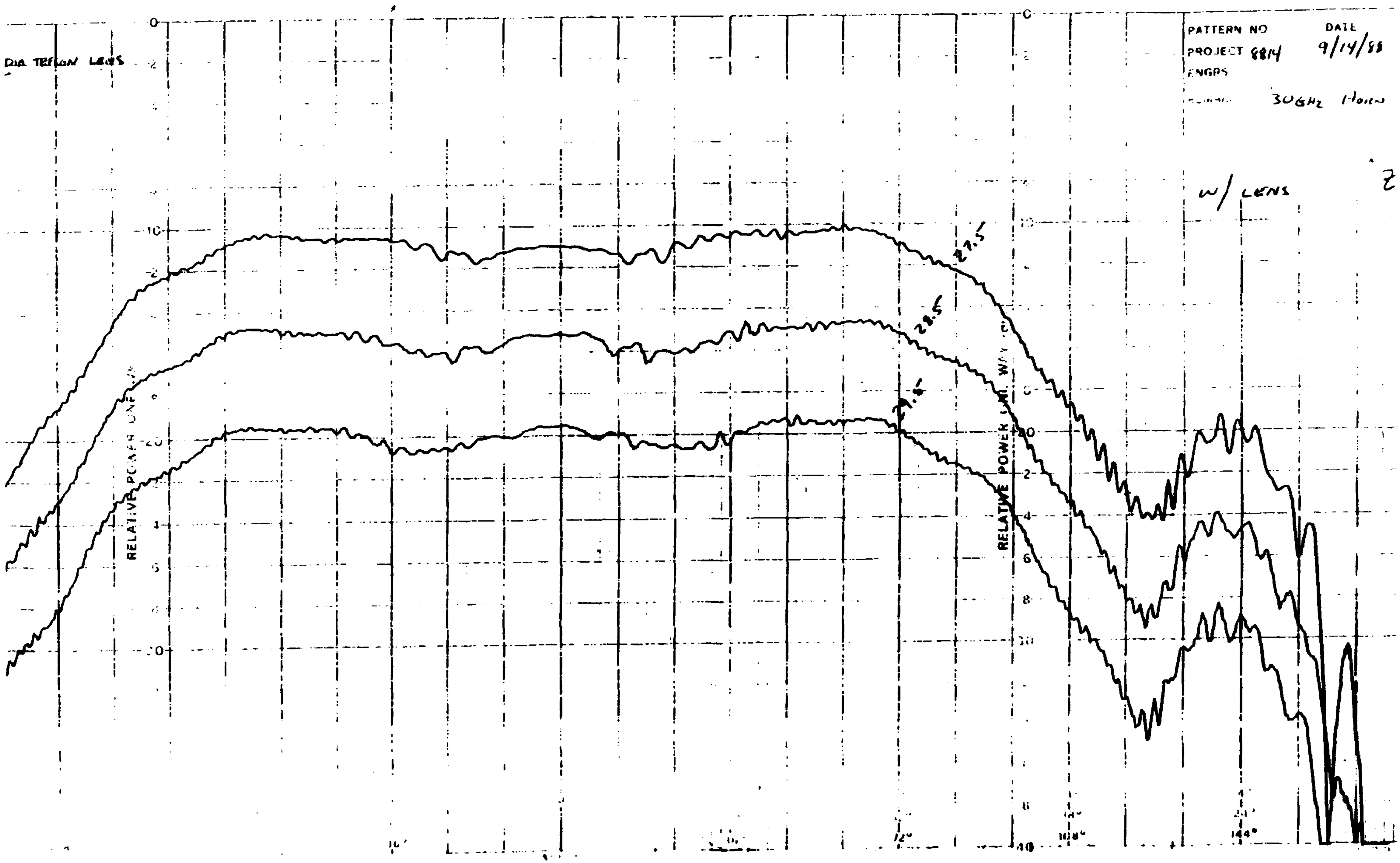
HEWLETT-PACKARD SCALAR NETWORK ANALYZER SYSTEM ~~8756A/S~~

Return loss at ports

Report No.

Figure No.


PATTERN NO.
DATE 9/14/88
PROJECT 8814
ENGRS
REMARKS 30 GHz Horn
w/ lens
27.5
28.5
29.5
RELATIVE POWER
ANGLE



DIA TEFLON LENS
PATTERN NO
PROJECT 6814
ENGRS
DATE
9/14/88
30GHz Horn
w/ LENS
2
27.5
28.5
29.6
RELATIVE POWER
108°
144°

3/29/87

Before the
FEDERAL COMMUNICATIONS COMMISSION
Washington, D.C. 20554

In Re Application of HYE CREST MANAGEMENT, INC. License for New Station in the Point-to-Point Microwave Radio Service in 27.5 - 29.5 GHz Band Toward Various Points in the State of New York	)	File No. 10380-CF-P-88

RESPONSE OF HYE CREST MANAGEMENT, INC.

Hye Crest Management, Inc. (Hye Crest) hereby replies to the comments/pleadings of the Bell Atlantic Telephone Companies (Bell Atlantic), National Spectrum Managers Association (NSMA) and Southwestern Bell Telephone Company (SWBT) filed February 28, 1989 with respect to an amendment to the above-captioned application dated January 25, 1989.

Bell Atlantic, NSMA and SWBT argue that Hye Crest should be precluded from immediately implementing the new communication services to benefit the public proposed by Hye Crest. These arguments are plainly in conflict with the Commission's most fundamental statutory mandates ". . . to make available, so far as possible, to all people of the United States a rapid, efficient . . . radio communications service with adequate facilities at reasonable charges . . ." and ". . . to encourage the provision of new technologies and services to the public."[1] Hye Crest is ready and able to implement its proposed communications services for the public but for the opposition of these parties.

Against the clear public benefits to be derived from inauguration of Hye Crest's proposed services, Bell Atlantic, NSMA and SWBT offer only speculation concerning possible future limitations on the shared use of the frequencies requested by Hye Crest in the New York Metropolitan area. They make no showings that any of them has equipment to use the frequencies at issue or, assuming for the sake of argument that any of them should be able to obtain such equipment, that any of them has projected requirements for communications on these frequencies.

The record in this proceeding clearly shows that there is no demonstrated telephone company need for 28 GHz spectrum in the New York Metropolitan area. The Affidavit of Jerry A. Hausman and the report, "High Capacity Transmission Alternatives in Lower Manhattan" by Charles L. Jackson ("Jackson Study"), prepared for NYNEX and entered into the record of this proceeding by Hye Crest as an attachment to its October 14, 1988 Response confirm that there is sufficient spectrum capacity in the 18 and 23 GHz bands to

[1] Sections 1 and 7 of the Communications Act of 1934, as amended, 47 USC 151 and 157, respectively.

interconnect all major buildings in New York City.[2] Nor does Bell Atlantic, NSMA or SWBT mention the fact that 1000 MHz of spectrum would remain available in the 28.5 - 29.5 GHz band in the New York Metropolitan area to meet any as yet undetermined future requirements or that the 31.0 GHz and above bands are available.

It is ironic that the parties opposing grant here must rely on arguments about hypothetical interference situations involving equipment which has yet to be developed for their use to meet communications needs which they have yet to demonstrate. Hye Crest has already shown that unavoidable harmful interference resulting from sharing of the 27.5 - 28.5 GHz band would be extremely rare, statistically insignificant, and can be avoided under the procedures established under 21.100(d) of the Commission's rules.

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2 "While there is substantial use of the 18 GHz and 23 GHz frequencies in Manhattan, the use is small compared to the total capacity of the band. Although the data base appears to show a large number of links, few of the links have been implemented and few channels on those links are actually being used. These two bands have an enormous capacity compared with lower frequency bands." (Jackson Study at p. 24.). . . and . . .". . . there appears, nevertheless to be sufficient spectrum space (in Manhattan, NYC) in the 18 and 23 GHz short haul bands to accommodate many new systems. We believe that essentially all major buildings could connect by microwave (18 and 23 GHz) to an interexchange carrier point of presence or to a building connected to Teleport's fiber optic network." (Jackson Study at p. 78). . . and . . ."However, for a number of reasons, we believe that it is feasible to connect almost any business location in Manhattan by microwave (18 and 23 GHz) to an interexchange carrier POP. Moreover, we believe that it is also likely that most business customers can be connected via microwave to buildings served by the New York Teleport Fiber Optic Cables." (Jackson Study at p. 53). . . and, "In summary, it seems highly likely that local microwave can be used in lower Manhattan to connect virtually any customer location." (Jackson Study at p. 54)

Particularly considering that there are vast amounts of available spectrum capacity for telephone company use in the New York Metropolitan area, the public interest supporting implementation of Hye Crest proposed communication services is clear.

The remaining technical disputes regarding hypothetical interference situations addressed by Bell Atlantic, NSMA and SWBT appear to result from misunderstandings which these parties have about operations in the 27.5 - 29.5 GHz band, with which they have no operating or developmental experience.[3] Through these proceedings, it has become apparent that Hye Crest transmitters have a statistically insignificant potential for interference to any telephone company point-to-point microwave link. The parties opposing grant here have now been forced to argue that Hye Crest's application should be denied because of a possibility that one of their transmitters might interfere with reception of Hye Crest's communication services. As discussed below, the latest round of arguments of these parties should be rejected because they continue to be based on erroneous or unrealistic assumptions and because they ignore the means readily available to the parties to work cooperatively to avoid frequency conflicts in the future in the event any such problems develop:

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[3] For example, their reliance on Commission rules governing the 2 GHz band is misplaced because it ignores the different propagation characteristics at 28 GHz band, narrower beamwidths, and different modulation techniques (i.e. 28 GHz employs FM) for video.